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# 03 Feb 24 Written Reflections Assignment

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Feb 24 Assignment:

Read: "Making Ice in East Indies" two articles.

1) Write a coherent paragraph on why this ice-making process works, using your understanding of phenomena and descriptions in the article.

2) The article also provides insights regarding sociology, economics, and culture. Write a comment about some aspect that struck you, citing evidence for your observation.

Read: The other linked websites are about various areas of application of the ideas we've been addressing. Choose two different topics from among the websites, read them, then write a paragraph that explains how the concepts we've been working with pertain to the applications you chose.

The choices were about: steam burn safety, protecting fruit crops by spraying with water during a freeze, beehive cooling, sweat, swamp coolers in homes

Each of these counts as a "reflection assignment" – see syllabus. Obviously, you can consult your notes.

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B26
Professor Chris Bauer
Fire and Ice
2/23/15

Assignment for Tuesday, Feb. 24

1. In the East Indies, during the summer months, the temperature can climb between 95 and 100 degrees Fahrenheit. To get ice for the summer, ice had to be harvested and stored during the months of December, January, and February. To make ice, first, large holes were dug on a large open plain. Of course, we know the freezing point of water is 32 degrees Fahrenheit, or 0 degrees Celsius. Because the temperature wouldn't necessarily fall that low, the people of the East Indies dug holes that were two feet deep. Immediately below the surface, the temperature is colder and having the water surrounded by compact dirt provided insulation from heat. They would then line the bottom of the hole with sugar cane and dried Indian corn, and they would place the water on small earthen pans. They most likely did this because these things were resistant to heat transfer. Because heat is a transfer of energy from one object to another, the water wouldn't freeze if it was placed into anything that caused a heat transfer. Boiling water was poured into the earthen pots. They most likely used boiling water because it has been observed that hot water freezes faster than cold water. This phenomena is known as the "Mpemba Effect", and it was Erasto Mpemba who observed that if you put two containers of water, one boiling and one not boiling, into a freezer, the boiling water will freeze first. The people of the East Indies would leave the pots with the water in these holes overnight, and in the morning they would come back to harvest the ice that had formed. By putting the water underground, and insulating the hole, the people of the East Indies were making the temperature cold enough for the water molecules to slow down and form back into a solid which was ice. Robert Barker made the observation that more ice formed on a calmer, warmer night than a night when the wind chill made the temperature feel colder. Scientifically speaking, no matter how cold the wind may make the temperature feel, water will only freeze if the actual temperature falls below the freezing point. Just because the wind may make it FEEL colder, in reality, on the calmer nights the temperature itself may have been colder, and that is why more ice was harvested on those nights. Also, as Barker mentions, keeping the water underground prevents the air from ruffling the water, which may cause the particles to disband. It seems as if the process of freezing ice becomes possible at a temperature above 32 degrees Fahrenheit when the water isn't receiving heat from any other bodies, or exposed to gusts of air.

2. What struck me most about these articles from a cultural and economic standpoint was the man power needed and the urgency that came with harvesting the ice. First, touching on the urgency and the need to make ice, these people live in a place where the summer temperature is routinely in the 90's. They have such a short window of time, approximately three or four months, to harvest enough ice to last their entire village through the summer. If they were to have an unseasonably warm summer, which I am sure they had, the already tedious process of freezing water and storing it would be made all that much harder. Harvesting ice has so many

implications for food and liquid storage, and the dynamic in quality of life could shift drastically for those people if they had not found a way to harvest and store ice. The level of man power it took to do this job is also something that I found particularly striking. John Lloyd Williams made the comment that there could be up to 100,000 pans exposed at one time, and that it took 300 men, women and children to fill the pots and harvest the ice each morning and evening. In what I would assume to be small tribes or villages, 300 people might be a large percentage of the population, and this speaks to the importance that these people placed on making sure they had enough ice to last them through the summer months.

3. The first article that I chose to relate to the concepts that we have been working with in class is the article pertaining to the cooling of the bee hive. This article discusses how honey bees regulate the temperature of their hives in order to protect their developing brood. When they are producing their young, they keep the hive at 95 degrees. To do this, the bees consume high energy food and they vibrate their flight muscles. This compares to what we have been learning in class using simulations and by performing experiments. We learned that as molecules speed up and their energy increases, the temperature in a container will increase. That is what these bees are doing; they are increasing their energy, speeding up their flight muscles, and using a high level of vibration to increase the temperature of their hive. To cool the nest back down, the bees spread out to allow for better air circulation. Instead of increasing their energy, they are decreasing the energy, which causes temperature to decrease. We saw this as well in the simulation. As we removed heat energy from molecules, causing them to slow down, we saw the temperature of the container decrease.

   The second article that I have read and can relate to the concepts learned in class is the article that deals with spraying fruit trees with water in the winter to protect the buds of fruit. The article talks about coating fruit trees with a thin layer of ice in the winter time to protect the buds from extreme cold temperatures. Fruit buds can withstand temperatures between approximately 32 degrees to 18 degrees. By coating the tree with ice, gardeners are able to maintain this temperature. There is heat that is released when liquid turns to ice, and if water is continually applied to the tree, the temperature of the tree can be maintained at water's freezing point of 32 degrees. I can apply this to the heating and cooling experiments that we did in class. When we graphed our results for the experiment, at each transition point, the slope of our graph evened out for a few seconds before it continued upwards or downwards. Based off of this article, it appears that at the point where our slope became 0, that is where this heat of fusion phenomena takes place. Because of this, it makes sense to continually apply water to the fruit trees, because if you keep adding water the tree will remain at the constant 32 degree temperature when the water undergoes a phase change.

C37
CHEM444 Fire and Ice
Reflection Assignments for Tues2/24

1. To begin the ice making process in the East Indies, excavation pits that are about two feet deep and thirty feet wide are dug. The pits are filled with either sugar cane or large stems from dried Indian corn. Shallow pots made of porous earth are then placed and in the late afternoon filled with water that had been boiled. In the early morning, some ice has formed and is broken into several pieces with an iron hook for it to be removed. The article describes the importance that the stems are dry and are replaced if they accidently become wet. It is important for the stems to be dry because the formation of ice has been prevented in the past on occasions where the stems were wet.

This ice-making process works because the earth is losing heat during the night because of radiation. The article describes that this process works best on nights where the weather conditions are clear and not windy. The serene weather and clear air is extremely important because it allows the cold of the night sky to effect the water, causing it to freeze. The phenomenon that is occurring is that the water is losing heat because it is being radiated upward. In return, the surrounding air would be gaining heat. On clear nights the heat would not be blocked by clouds and sent back, preventing the water from freezing, which is why cloudless weather conditions are ideal for this process to occur. It is my understanding that the earth losing heat to the surrounding air above is why this ice-making process works. There is evidence for this phenomenon in the article. It is stated that on nights where ice was formed, a thermometer placed five and a half feet above the stems had a temperature reading that was four degrees higher than the temperature of the thermometer that was placed on the sugar cane stems. This temperature difference supports the idea that the earth is losing heat while the above air is gaining heat. The loss of heat creates a temperature low enough for the water to experience a phase change and thus the formation of ice occurs.

2. One economic aspect that struck me as very interesting was that this ice making process has actually created jobs for the people in the East Indies. The “Account of the Method of Making Ice at Benares” article written by John Lloyd Williams discusses this. The article states that ”about 300 men, women, and children” are employed because of this ice-making process. People are employed to fill the pans with water and to take out the ice in the mornings. Individuals are also needed to ensure the stems are dry and that they are replaced if they become wet or else the ice-making process will not work. As an effect of the ice-making process, a variety of people, even children, can be employed who may not of otherwise had a job they could perform. I find it intriguing how such a phenomenon exists that allows this ice-making process

to work and in turn the people and economy of the East Indies are able to benefit.

3. The "Cooling the Bee Hive" article discussed how the honeybee colony is able to regulate the temperature inside of their hive. The concept behind how the honeybees are able to control the temperature of their hive is very closely related to the temperature and phase change ideas that we have been exploring in class. For example, when warm weather is being experienced, the honeybees can decrease the temperature and essentially cool off their hive. The main cooling process consists of they honeybees carrying water into the hive from outside sources and fanning the water with their wings. The water will undergo a phase change from a liquid to a gas and will evaporate. The evaporation of the water is what causes the beehive to be cooled down. This is because in order for the water to evaporate, it draws heat from its surroundings to undergo the phase change to a gas. It is my understanding that the water is gaining heat while the air in the hive is losing heat and therefore the temperature in the hive will decrease. This is closely linked to the experiment we performed in class on Thursday with the can of cleaning spray. The can contained a liquid but when sprayed a gas form came out of the can. You could also feel the can becoming colder. This experiment displayed the same idea as the cooling of the beehive. In both cases the liquid gained heat to evaporate into a gas while its surroundings, either the can or the hive, lost heat.

The "All About Sweat" article is also linked to the applications that we have been addressing in class. This article explains how sweating is our bodies' process of cooling down by a process of removing excess heat. When we sweat, the sweat evaporates from the surface of our skin and therefore cools our body. In order for the process of evaporation to take place, a certain amount of heat needs to be present. I believe this is why our sweat takes heat from our body so it can reach the necessary temperature to evaporate. As a result, our body is cooled off because it is losing heat. The molecules in the liquid form of sweat are able to speed up when they experience an increase in heat energy due to the temperature increase, and thus the sweat will evaporate into a gas. This process of taking in heat energy from the surroundings to increase the speed of the molecules and cause a phase change is the main idea behind sweating. This idea is also linked with how the honeybees cool their hive and the experiment with the can of cleaner from class. The underlying fundamentals are the same behind all of these ideas. Heat energy is needed to speed up the velocity of the molecules and break the bonds of the substance to cause the phase to change from a liquid to a gas. The surroundings therefore lose heat to the substance that is undergoing the phase change. It is also discussed in the article that sweating best cools your body when the air around you is dry. I believe this is the case because the air already contains water vapor when it is very humid out so it will not take vapor in as easily as when the air is dry. The evaporation rate of our sweat would be slowed. Not as much heat would be drawn from our

body to the sweat to allow for evaporation and as a result our body would not be cooled as much. This demonstrates how different environments can affect the phase change process. This is also seen in the ice-making process article because the process is unable to occur on cloudy or windy nights.

Hi Sir,

I was having trouble with my personal computer and so I wrote this up in a computer lab, and for the life of me could not figure out how to send it as a file. I hope this is okay. thank you,

D24

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I am not a hundred percent sure that I fully understood the process as it was described. I believe if I understood it correctly that the water freezes because of the evaporation that occurring on the outside of the basins. The basins are porous and therefore allow small increments of water to seep through the basin. Insulated and kept relatively warm by the sugar cane the water evaporates of the bowl, taking heat from the bowl and the water contained therein, allowing it to eventually drop below freezing and create ice. If the sugar cane was wet, it would not be a insulator and therefor no evaporation or not enough evaporation would occur to reach freezing temperatures. Same as when there was wind or cold temperatures, there would be less ice, because less evaporation would be occurring.

Regarding the 300 hundred workers women and children, obviously this shows the economic value in the ice in such a warm climate, but is also probably a demonstration of the almost slave labor level in such towns.

Protecting the fruit trees by freezing them is a demonstration of heat transfer during phase changes. That process only works because as the water turns to ice heat is released from the water into the tree, maintaining a healthy temperature. It goes on the explain that in order for this to work effectively the tree needs to be sprayed with as little water as possible to cover the entire tree and freeze efficiently to raise the temperature of the tree.

The bees essential create their own swam coolers. They bring in droplets of water, and by fanning the water with their winds in the heat; they raise the rate of evaporation, and can cool the hive down to maintain their optimum hive temperature.

MAKING ICE

In the East Indies the process of making ice, at a temperature where water has not been known to freeze, is a very specific process and part of the lifestyle from December to February. Four acres of land is cleared out, divided into square sections, resembling a modern day ice cube tray, and covered with layers of dry straw and butter for several days in a row to form a solid mold and prevent the ice from sticking. The water is poured in unglazed earthen pans placed on the straw in the afternoon, at a five in the morning, the time in which the cold is at its peak, iron hooks are thrown into the blocks of ice, smashing them into pieces, and ready to be removed. Around 100,000 pans are exposed at once from 300 workers; men, women, and children. It is essential that the straw be dry in order for this process to work, so a careful eye is kept on the straw. Williams explain the reason behind this process being effective in an example regarding a china plate. Water that is boiled and put to freeze on a china plate will not freeze, whereas well water placed on a straw bed will. However any moisture at all on the straw bed will prevent the freezing process. In order for ice to form there needs to be still air, and when measured at these straw beds, when there was no wind, the temperature of the bed was four degrees lower than that of the air five feet above it, yet with wind the temperatures were the same. I was interested to learn that Williams didn't even want to offer any explanation as to why the water froze at a temperature so much higher than the freezing point (37-42 degrees), but instead left it very open. Most of the articles we have read have at least given some inkling as to the phenomena, and he just provided data and explained, "I shall offer no opinion" (Williams, 1793, p. 58). When Sir Barker explains this scenario, he elucidates that he cannot be sure that the temperature does not ever descend to the freezing point because he has never made the appropriate observations. However he is certain that in every situation except the exact one described above in those particular pans, the water will not freeze. He gives reason to the importance of the dry straw, begin that its spongy nature allows cold air to pass under them, which when surrounding the vessel, can allow for cold air to get inside the vessel, especially at about a foot under ground level. When water is in a scenario in which is does not receive any heat source from other bodies it is able to freeze at a temperature above the freezing point, Barker explains.

ALL ABOUT SWEAT

In class we have discussed a lot about how heat is generated and where heat comes from, but we have yet to discuss at length where heat goes and how it leaves the body, for example in terms of sweat. The article explains how at cool temperatures, there is low sweat production and the body has enough time to reabsorb the sodium and chlorine from the ducts before they are secreted. However, at a hot temperature, there is high sweat production there is not enough time to reabsorb the sodium and chlorine before it is released through sweat glands. This article explains why when we sweat, it is actually cooling our bodies down. When water is converted from liquid to vapor, the amount of heat necessary to do so is called the heat of vaporization. An increase in heat increases the speed of the molecules so they can disperse into the air. However not all of the sweat is lost through evaporation, some just rolls of the skin like water. Just as not all of the sweat is lost, neither is all of the energy through sweat, some is simply radiated

from the skin and some is lost through the respiratory system. The amount of sweat able to be evaporated has to do with the humidity of the air. If the air is humid, there is already water vapor in it, and not much room for more to be absorbed, so dry air is optimal for efficient evaporation. When sweat evaporates, it leaves the salts on your skin, making it salty, and if you do not drink enough liquids to reabsorb those salts, you can become dehydrated.

PROTECTING FRUIT

It has been found that spraying a tree with water before a freeze is supposed to hit, covering the fruit and tree with ice, can serve as a protective measure for the fruit buds. When water goes from the liquid to solid stage, there is an amount of heat that is released, called heat of fusion. When water freezes, it releases enough energy (80 calories per gram of water) to keep the temperature sensitive buds at around 32 degrees Fahrenheit, therefore protecting them from damage. It isn't as simple as it seems however, and it can be quite a balance, because variables such as wind, humidity, and water vapor, take away the energy from the ice, and do not supply it to the plants, resulting in the plants not being able to stay as warm. In order to get the right amount of ice on the plants, not too little that they are unprotected, and not too much that it causes more cooling before heating, microsprinklers are used. The article advises caution because different stages of bud development can handle different amounts of heat loss and temperatures. Overall, the ice is able to trap heat inside the bud, and counter intuitively keep it warm.

G33

CHEM 444

February 21, 2015

## Making Ice in the East Indies Assignment

1. This process of ice-making was successful mainly due to the environment in which the process took place. The workers dug holes in the ground, which held the water that would turn to ice. This was a suitable location because the temperature underground is lower than above ground. Another way of thinking about decreased temperature is decreased kinetic energy. As the kinetic energy decreased, the molecules moved slower. This also contributed to the formation of a solid from a liquid. The low temperature in the ground is what aided in forming ice from the liquid state of water.
2. One aspect that surprised me was the inclusion of economics in the letter written by Robert Barker. He said that "the promising advantages of such a discovery… [can lead to our citizens] procuring themselves to a comfortable refreshment… to alleviate, in some degree, the intense heats of the summer season" (Barker, 256-257). This comment relating ice to being an economic advantage to the country surprised me. Currently, ice is not related to any sort of economic status. However, back before refrigerators and freezers existed, ice boxes were used. A man would deliver ice to homes. To be fortunate enough to have ice to place in your lemonade in the summer was a luxury. It is easy to forget that this is true, when ice is very accessible to us all year round at a notably inexpensive cost.

Citation:

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## Reflection Assignments

1. Topic 1: Sweating
   The purpose of sweating is to cool your body down. In the case of exercise, sweating is a release of the excess heat that is produced from hardworking muscles. When your body sweats, the sweat is evaporated, which is what allows you to feel cool because the evaporation of the liquid removes excess heat. When evaporation takes place, a liquid is changed into a vapor/gas. This is a phase change. This connects to concepts learned in class, because we have addressed the changes that occur in different states of matter. We have discussed the molecular activity of each state of matter (the speed and structure of molecules in solid vs. liquid vs. gas), the effect of temperature on each state, the properties of each state, and which factors can cause phase changes.

The molecular activity of a solid is that the molecules are close together and hardly move. The molecular activity of a liquid is that they are separated and move a bit faster. The molecular activity of a gas is that the molecules are spread out and move very fast, continuously bouncing off of their surroundings. Increasing temperature in each state of matter makes the molecules move faster, as it transfers energy to the molecules. A factor that can cause a phase change is adding or removing heat. It is strange to think that sweating is due to a phase change of a substance, but after reading the article and comparing it with the concepts in class, it makes more sense that the two concepts are closely related.

2. Topic 2: Is steam or boiling water more dangerous?
   The findings of this website suggest that steam is more harmful to your skin than boiling water. The rationale behind this is that steam has more energy, since it is a gas. This coincides with what we have learned in class. Similarly to topic one, this topic also deals with states of matter. This specific question is comparing liquid and gas. As I have learned in class, the energy is increased in a gas compared to a liquid. This is because the molecules move faster in a gas than in a liquid. An increase in temperature is what makes a liquid change to a vapor. Also discussed on the website was the latent heat of vaporization, which is the amount of heat required to change a liquid to a gas. The increased energy in a gas is what causes steam to be more dangerous to your skin surface than a hot liquid. Regardless of the temperature of the liquid, the gas still has more energy.

H22

CHEM 444A

Professor Bauer

2/24/15

Reflection Assignment

1.) The two articles have many similarities in the process of making ice, but they also have some substantial differences. The overall observation is that ice is being formed even though the temperature isn't dropping all the way to the freezing point. With the being said special preparation is taken into account to make this possible. Water is placed in "bowls" which are extremely porous. These are porous to prevent them from holding any heat and allow the water to wet the outside of the bowls. As described in the article the bowls are placed in an area which is below the surface of earth to prevent wind from moving the particle alignments as they attempt to "settle". Another precaution which is taken is "suspending" the bowl so that no heat from the Earth transfers to the bowl. Each area which contains these bowls is "lined with sugar cane or dry straw". In the article, J.LL. Williams notes that the straw must be dry in order for the ice-making process to work. I believe this is because the water would evaporate into vapor which would have a higher temperature thereby heating the bowls and preventing freezing. These experiments where performed during the time period of December to February when the temperature was at its coldest. As the temperatures where near freezing, but not at the freezing point, this alone couldn't cause the water to freeze. As mentioned earlier the water would dampen the outside of the porous bowls. The thin layer of water on the outside of the bowls would undergo a phase change, liquid to gas, as it evaporated. From readings and the

experiments in class, I discovered that the temperature decreases as a phase change is occurring. Therefore the decrease temperature around the base of the bowls drops the temperature just enough to get to the freezing point, allowing ice to form. There are many key components including the molecules being undisturbed allowing bonds and patterns to be formed, no transfer of heat from the environment to the water, and the porous bowls allowing a phase change to occur dropping the temperature enough to freeze the water. It is also pertinent that the surrounding air has very low humidity. This low water content in the air encourages evaporation since the moisture from the water transfers from a liquid into the dry air; evaporation. The air has very little moisture thereby attracting moisture from the water causing evaporation. The temperature drops since the heat energy is used to change phases, resulting in lower temperatures of the water. I can support this theory by referring to our experiments with the aerosol can. Inside the can was a liquid. As the liquid was released a phase change occurred which substantial decreased the temperature of the can. Another factor of this theory is that as some of the water evaporates some heat is removed also because of the evaporation which even further decreases the water's temperature. The energy needed to cause the phase change is withdrawn allowing the temperature to decrease.

2.) I made a few observations of sociology, economics, and culture when reading the two articles about the ice-making process. The first being how large groups of men along with women and children where used in the ice-making process to disperse the water into bowls each night. Also I found it interesting how they planned to use the ice to help make the summer heat more bearable. The article discusses how they "specialize in luxuries", this invention of the ice-making process being a great way to "alleviate the intense heats of the summer season" (Barker).

I propose there to be a great economic benefit to selling ice in an area that experiences such intense temperatures the majority of the year. I found it very interesting how the general idea of "air-conditioning" was generated several hundred years ago, and used for economic benefit.

Reflection #1: *Sweating*

Sweating is an important function of the body to help cool the body when its temperature increases. Sweating can occur as a result of physical activity or even "increased stimulus". The concept of sweating relates directly to the process of "ice-making" in the previous articles. As the body increases activity it begins to release fluids, containing salt and potassium, through sweat glands located all over the skin (Freudenrich). As a result there is fluid on the surface of the skin. The fluid on the skin evaporates into the drier air, as it undergoes a phase change. In comparison to the "ice-making process" these effects work more efficiently if the air has low humidity content. This is because the air will contain little to no moisture, attracting the moisture on the skin. As a phase change occurs more and more energy is needed to change the state of the substance, therefore lowering the temperature since the energy is being used solely for the phase change. This is known as heat of vaporization. For example I can compare this to the experiment we performed on Thursday, February 19th. In particular as the "aerosol" can was sprayed the container, which we can compared to the human body, became cooler the longer it was sprayed. This is because the state of the substance was changing from a liquid, the sweat, to a gas, vapor. This can be seen by referencing the charts we created showing the phase changes as temperature increases. There are very distinct portions of the graph which "level out" and represent phase

changes. The temperature decreases since energy is being pulled away in order to facilitate these phase changes. This topic relates directly to our current area of discussion since it involves the behavior of heat/energy and its effects when a substance undergoes a phase change. When we used the thermochromic paper we worked with the idea of colder temperatures at the sites of phase change. When the ice on the thermochromic paper turned to liquid the color changed to a purplish color, but always staying a darker tint. When the liquid changed to a gas the paper turned a brighter color since the temperature was even colder at those sports because of the heat energy being used. As seen from our experiments, readings, graphs, and posters, phase change undoubtedly causes a change in the temperature, thereby allowing water to freeze above the freezing point or allowing our bodies to be cooled though evaporation.

Reflection #2: *Protecting Fruit Harvest From Freeze*

I found this article to be extremely interesting as it introduces a fascinating concept while correlating with the topics we are currently working with. As discussed in my first two paragraphs when water changes from a liquid to a gas or vapor the temperature decreases since the energy is being used to change the state of the substance. The effect of spraying trees with water to protect them from cold temperatures uses the exact opposite approach. As water changes states, from liquid to a solid heat is generated. This theory can be supported from facts in the article showing that the temperature rises and also by viewing the graphs we created during class. As we saw during last Thursday's experiments, what we were performing related directly to what our posters were visually displaying. By looking at each visual the fact that the temperature stops decreasing and actually increases some as the substance changes from a liquid to a solid can be observed. My two reflections have opposite ideas as the first relates to the heat

of vaporization, the heat lost when a substance changes from a liquid to a gas, and this relates to the heat of fusion, the heat created when a substance changes from a liquid to a solid. These two ideas explain why the aerosol can felt cooler and cooler and also why the thermochromic paper displayed that temperatures were cooler where the water was evaporating even though the "room temperature" was held constant. This concept brings clarity to the recent experiment. This concept of heat of fusion explains why fruit trees can actually be protected from cold temperatures by spraying them with water prior to the cold weather allowing them to freeze. If this is done properly heat will be generated as the water freezes and undergoes a phase change keeping the tree warm while the ice could act almost as an insulator to retain some of the heat. This topic relates to what we are working on since it connects the relationship between phase change and either the generation or loss of heat. The article discusses an important "balance" between evaporation and freezing. This thought ties together our ideas from class and the readings for this assignment as well. A balance is necessary since if there are a lot higher rates of evaporation compared to freezing, the plant will actually be hurt even more since the temperatures will be even lower. Evaporation lowers temperatures will freezing raises them therefore the proper "balance" is imperative.

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J31

Chem: Fire and Ice

02/24/2015

Making Ice in East Indies

Ice can be made at degrees higher than freezing. These ice making techniques work best when the air is dry. The air looks to moisturize itself and thus evaporates some of the water. However, in order to evaporate water energy must be transferred into the water molecule and in this process energy is removed from the surrounding water and atmosphere. The cooling that comes as a result of the evaporation causes water to freeze. In the East Indies it was said to be best if "soft" (boiled) water was used. This water would be more susceptible to the evaporation process. However, in Benares it was stated that it did not make much difference whether or not the water was previously boiled, the icing still occurred.

In the East Indies and Benares natural ice is extremely rare. In places of cooler climate we take this for granted – ice is used for many things from preserving food to treating injuries. Processes as explained must be relied on for ice in these climates of higher temperature. In Benares they relied heavily on the new ice making process using "100,000 pans at a time and employing the help of 300 men, women, and children" to fill and empty the pans.

PhysLink.com 100◦ Steam More Injurious to Skin than 100◦ Water?

This article explains how 100◦ steam is much more dangerous to skin than water at the same temperature. It requires 540 calories more to convert a gram of water into steam. This is related to what we have been working with, because in doing the heating and cooling

experiments questions were formed as to why the rate of temperature increase slowed considerably around the phase change temperatures. This article explained that while it takes 63 calories to heat water from 37◦ to 100◦, it takes 540 calories to heat water into steam without altering the temperature. Thus, while acquiring the necessary calories to change states temperature is unable to increase, accounting for the slowed rate. The article went on to explain that in addition to being of greater damage because of the added energy and calories, one would also have to experience the 100◦ water along with the steam experience, because steam turns back into water when the condensation process occurs.

SF GATE Why Spray Fruit Trees with Water before a Freeze?

The spraying of water on fruit trees can help to keep the fruit buds from freezing on frigid nights. "When water freezes, heat is produced at a rate of 80 calories per gram of water," this heat is then transferred to the fruit buds helping them to maintain a good temperature. This is related to the concepts we have been studying when we examine how temperature, state change, and energy are related. This article shows how in order for the water to become ice, heat must be released to create a phase change, thus serving to warm the fruit buds. We see that in order for a substance to drop to a lower phase it must release energy, thus providing energy to the environment it is in. In a similar and opposite manner, if a substance is to go from liquid to gas it must take in energy from its environment.

K29
February 24, 2015
Reflection Assignment
Fire & Ice

Ice is made in the East Indies by placing water in earthen pans, which reside in two-foot deep pits that are covered with a layer of sugar-cane or the stems of corn. The earthen pans are filled with water around dusk and any ice that has formed is taken out of the pans before the sun rises. These small pieces of ice are then placed in fourteen to fifteen-foot deep pits, which are insulated with straw and blankets, until the ice forms one solid mass. At first it would appear that the ice forms because the water is placed deeper into the ground, where the temperature is usually cooler than the air. However, the earth still would not reach a temperature below the freezing point, especially since the pits are only two feet deep. The temperature of the air also does not affect the formation of ice. Sir Robert Barker remarks that the most ice is formed on clear nights when the atmosphere is lighter, rather than when there is coldness in the air. This is an interesting observation because it would seem logical that more ice would be made on colder nights. With this knowledge, Sir Robert Barker hypothesized that evaporation may occur and subsequently cool the air enough for water to form into ice. The sugar-cane or corn stems would act as a "passage under the pans to the cold air… [and] may carry off by evaporation a proportion of the heat." This explanation seems to be logical because evaporation does in fact cool the air. However, John Lloyd Williams observes that the straw or sugar-cane must be dry for the formation of ice to occur. He experimented using wet straw and no ice had formed. If the straw was wet it would actually aid in the process of evaporation. Evaporation must not be the cause of the water freezing because ice will not form when the straw is wet. The formation of ice must be correlated to Sir Robert Barker's observation of the atmosphere when ice forms and when ice does not form. On clear nights when the atmosphere is lighter, the ice is able to form. On nights when the atmosphere is cloudy or windy, even if the temperature is cooler, the water does not freeze. I hypothesize that ice is able to form on clear nights because the heat given off by the earth is not blocked and re-projected back to the surface of the earth. The straw is able to keep the earth at the cool temperature that is created by the loss of heat.

The cultivation of sugar cane and the production of sugar has been an integral part of the Indian trade and economy. It was discovered in India to turn sugar cane juice into granulated pieces. Sir Robert Barker was observing the ice making process in India. The pits, used for making ice, were lined with either sugar cane plants or corn. It seems that the sugar cane plants had more than one use in India. http://en.wikipedia.org/wiki/Sugarcane

K29
February 24, 2015
Reflection Assignment
Fire & Ice

In the article, “Steam Burns”, it is said that steam is more injurious than boiling water. This is because steam has more energy than boiling water. In class and in the Phet Simulations the transfer of energy as heat has been the main topic of discussion. There is a certain amount of energy needed to change a substance’s state. The article describes this amount of energy as the latent heat. The latent heat has been observed in the Phet Simulations and in experiments. In the Phet Simulations when a certain amount of heat is added to a substance the particles will begin to move more quickly until a phase change has been completed. The amount of heat needed to change the movement of particles is different for every substance. In class, groups were given various substances to heat and cool and timed how long it took the substance to reach a certain temperature. The latent heat of a substance explains why it took the substances different times to reach a specific temperature. Therefore, it makes sense that the graphs, which depict the heating of various substances, all look different from each other. It would take the same amount of energy and time to heat all the substances if latent heat was a constant amount.

The ideas being discussed in class can also be related to the article, “Cooling the Bee Hive.” The bees in a colony need to keep the temperature of the hive at 95 degrees when they are developing the brood. In cool weather, the bees will huddle into the hive and vibrate their flight muscles to heat up the hive. This method of heating is related to topics being discussed in class. When there is increased motion and contact between particles, heat will be produced. This occurs because as particles speed up and motion increases the heat will also increase. By vibrating their flight muscles the bees are making molecules increase in speed and motion, which heats the hive. The bees vibrating their flight muscles are similar to what occurs if one were to rub their hands together. In order to cool the hive the bees will fan their wings over a droplet of water. As the droplet evaporates the air in the hive will cool down. The droplet changes state from liquid to gas, which has been observed in the Phet Simulations. The molecules in the water droplet are moving slightly and are organized into a cluster, but when evaporation occurs the molecules have lost their formation and move quickly and freely.

L18

Professor Bauer

Chem 444H

February 23, 2015

For Tuesday the 24th

Making Ice in the East Indies:

After reading the articles on how they made ice in the East Indies, I can completely understand these scientists' infatuations with this phenomenon. From what I understand, the ice is allowed to form because water evaporates in these shallow pans, which removes heat from the remaining liquid, allowing it to freeze. The set up of the pits allows for minimal heat to be transferred from the earth to the pans, and it also prevents any agitation from strong winds or anything, which would keep the bonds from forming for the water to freeze. It also talked about how the atmosphere had an effect on the freezing. They said it worked best in a light atmosphere, which I believe corresponds to low humidity, meaning there is not a lot of water vapor in the air already. I think this would allow for water to evaporate more readily from these shallow pans, and as minimal heat is added to the system, the evaporation takes heat away, resulting in the freezing of the water. This process obviously required certain conditions such as low temperatures and calm, clear weather, but it is still shocking how well it worked. The second article had a less involved set up but still proved effective, this time including the butter as a lubricant, but likely did not have much effect on the freezing. I think that the crucial parts of the set up were the straw beds below the pans, the shape of the pans themselves, and the atmosphere. The combination of these three things resulted in the production of ice without the atmosphere being zero degrees Celsius. Towards the end of the article, Barker mentions that

they could make a profit from this scientific process. Economically, ice would seem like a very valuable commodity in such a location, so producing and selling this could have been quite profitable. I'm not sure how abundant water is, but I find it very interesting that someone could make money off something that did not cost them very much to produce. Obviously the value comes from the process, which once mastered could have made someone in the East Indies back then pretty rich.

Cooling the Beehive:

I found this article particularly interesting because even though it took scientists many years to develop a thorough explanation of this concept, bees are able to apply the concept instinctively, although they could not explain it. This article talks about how bees keep their beehive cool on the hot days of summer. The most effective method, which pertains to our learning, is that they bring in drops of water from the outside then fan their wings over the droplets and let the water evaporate. This evaporation absorbs heat and when the water vapor leaves the beehive it results in a lower temperature on the inside. This is the same concept that allows ice to freeze in the East Indies, and that we have been studying the past couple days. I found it interesting that the bees recognize when the hive is getting too hot and will stop collecting nectar and start bringing in water. Another way they cool it down is by spacing themselves out allowing for air flow in the hive, which allows for heat transfer by convection, thus cooling the hive. It is also interesting to note how they heat it, by clumping together and vibrating their wings.

Why Spray Fruit Trees With Water Before a Freeze:

This article discussed a veteran gardening practice, which involves coating your fruit trees with water prior to a night that will bring freezing temperatures. This method is effective

because heat is released at a rate of 80 calories per gram of water when water freezes. This is what is known as the heat of fusion. This is the opposite of the concept that we have been talking about, which is the absorption of heat by evaporating water. The reason this article is pertinent to this topic because the gardeners must be careful, since the water evaporates as well, especially when it is windy and humidity is low. This evaporation draws heat way at a rate of 596 calories per gram, which is clearly much greater than the heat released from freezing. According to the article, this means that for every gallon of water that evaporates, 7.5 gallons must freeze in order to keep the fruit from getting colder. The method to combat this issue is by using microsprinklers, which provide just the thinnest coat of water, which freezes very quickly and provides the ice coat necessary to protect the fruit.

M27
February 21, 2015
CHEM 444A

**Reflection Assignment**

*Making Ice in the East Indies*

Throughout our exploration of heat, temperature, and phase change, we discovered the underlying relationships connecting these three concepts. As heat is added to a system or a substance, the temperature rises; once the temperature reaches a certain point, the substance changes phases, either a solid to a liquid or a liquid to a gas, known as the melting and boiling point respectively. On the opposite end, removing heat results in the reverse occurring, a gas condenses to a liquid and a liquid freezes to a solid. Although these points are commonly associated with temperatures, other factors can interfere with the system, causing phases to change at temperatures that differ from the given points. One of these factors is air pressure, which may explain the articles about ice being made in the East Indies. Two articles were published by scientists regarding the freezing of water at points higher than 32°F, the freezing point of water. The process of freezing water was always carried out during December, January, and February, and the same results were found over several years. In the PhET simulations, we experimented with the addition and removal of heat, as well as pressure, and we examined how these two elements affected molecules. Since water was capable at freezing at temperatures above 32°F, it is possible that the pressure in the East Indies during these months were lower, thus affecting the natural phenomena. As pressure increases, the freezing point of a substance can rise.

The process of making ice described in the articles provided more details than solely focusing on the science behind it. As mentioned in Williams's account of the procedure, three hundred men, women, and children, are employed by the ice making practice, and roughly one hundred thousand pans are exposed at one time. Making ice in the East Indies was a significant task, and involved many people; it almost seems like a manufacturing business. Ice making did not only impact science; it impacted the culture as a whole.

*All About Sweat*

Sweat is a common bodily function in which we secrete fluids from our body through glands on our skin. This process is natural and necessary in order to maintain our body temperature. The act of perspiration is our body's way of cooling itself down. During this process, the fluid produced evaporates from our skin's surface, thus removing excess heat and leaving a cooler and more refreshed feeling. Perspiration is a phase change because it converts a liquid to a gas. As we have learned in the classroom, heat is required in order surpass the phase boundaries. In the situation of sweating, a certain amount of heat is required to turn the liquid form of sweat into a vapor. The water produced as sweat, which forms on your skin, absorbs the heat coming from your body, which is elevated due to exercise or being in a hot environment. In order to feel cool after sweating, one must allow the sweat to gain enough heat to break the bonds formed in the liquid, allowing the water molecules to move freely at a greater speed. Once the water molecules have gained enough heat, they will evaporate into the air, and take the heat

from your body with it, resulting in a cool feeling. If the surrounding air is humid, meaning that it is comprised of  a lot of water vapor, it is more difficult for the sweat to evaporate and the sweat stays on our skin much longer.

*Cooling the Bee Hive*

Humans are not the only beings concerned with temperature regulation. Honey bees must maintain a certain temperature within the hive to protect the developing young. In warm temperatures, bees have established a process that mimics the way humans cool themselves. In order to cool the hive, the bees go out and collect water instead of nectar. The honey bees bring the water inside the hive and flutter their wings across the droplets of water. By doing this, the bees are generating heat around the droplet, which causes the temperature of the water droplet to rise. At the molecular level, the particles are gaining energy from the bees' wings, and the average speed of the molecules increases. The increase in speed helps the bonds between the particles to break, turning it from a liquid to the gaseous phase. When enough heat is transferred to the droplet, it evaporates; each particle takes excess heat with it, resulting in a cooler temperature within the hive, leaving the bees cool and comfortable.

Tuesday, Feb 24 Assignment

**Three things to write about:**

**Read: "Making Ice in East Indies" two articles.**

**1) Write a coherent paragraph on why this ice-making process works, using your understanding of phenomena and descriptions in the article.**

The ice making process in the East-Indies was clearly very well thought out by the pioneers that first made the ice. The key to the freezing of the water is due to several factors. For one, since each square dug into the ground is lower than the ground level and is protected by walls, wind and other exterior air factors are made secluded, so the water pans remain protected. Perhaps the most important factor that allows this water to freeze is the porous Indian corn and sugar cane that lines the base of each water hole. Since these materials are very porous, they allow air to travel underneath the water pans, and when the air is trapped in the porous materials, their temperatures drop due to protection from the exterior.

**2) The article also provides insights regarding sociology, economics, and culture. Write a comment about some aspect that struck you, citing evidence for your observation.**

I thought the most noticeable factor about the ice making process was the amount of work that was required to maintain the process, and where that work came from. In the "Account of the method of making ice at Benares" written as a letter by John Lloyd Williams, he describes that around 300 men, women, and children would work daily on this ice process, doing a variety of manual tasks that would surely be tiring. These tasks included waking up a 5am to collect and further-produce the ice, lining the pans with butter to prevent the ice from sticking to the pans, filling the pans with water each night, and changing out any wet pieces of sugar cane straw. There were around 100,000 of these pans, and these individuals had to maintenance the pans every day.

**Read: The other linked websites are about various areas of application of the ideas we've been addressing. Choose two different topics from among the websites, read them, then write a paragraph that explains how the concepts we've been working with pertain to the applications you chose.**

The first article I read was "All About Sweat" written by Craig Freudenrich, PhD. This article was very informative because it described everything related to sweat, including what happens during the process of sweating, what substances are in sweat, and why humans sweat. Lately in class we have been exploring state change, and before reading this article, I had no idea that state change was actually the key behind why we sweat. Instead of the liquid cooling your skin, it is actually the evaporation of the sweat that results in cooling. When sweat is secreted through the skin, it is in a liquid state resting on top of the skin, but evaporation allows the molecules in sweat (which are warm from your body) escape into the air, which cools the skin. The next article I read was "Cooling the Beehive" by Richard Underhill. This was an interesting article about how bees control the temperature of their hive. Relating to the "All About Sweat" article

and the effects of state change, when the bees need to cool their hive, they bring in water so it will evaporate, which makes the heat escape the hive into the air. The bees also spread out, decreasing friction. Also, they consume lower-energy foods, to keep energy level lower which leads to a colder temperature.

CHEM 444AH Reflection Readings

P14

February 24, 29015

*The Process of Making Ice in the East Indies* - Sir Robert Barker 1775

In a place where it is too warm for ice to occur naturally such as the East Indies, it would seem impossible that ice could be made. However a process is used that allows large quantities of ice to be produced naturally. Shallow pits are dug in a large field where the roots if sugar cane and corn lay among the base of the pit. The pits are lined with some sort of blanketing and pans of water are placed in the pit. A straw blanket covers the mouth of the pit. Overnight when the temperature drops, much of the water in the pans freezes, as it is protected from exterior conditions and heat by the straw and blanketing, allowing only the cold air to reach the water.

In the end of the article, it talks of the cultural and economic consequences of such a discovery. In the height of the summer, the ability to produce ice in such a natural way can provide comfort to those who are facing intense heat.

*Cooling the Beehive* – Richard Underhill 2009

In order to create suitable environments, bees must maintain proper temperatures in the hive during the summer and the winter. During the summer when the larvae are incubating, the bees must maintain a constant 95º by eating high-energy foods and vibrating close to one another. This lines up with our exploration of temperature. It being a relative measure of the amount of kinetic energy in a system, the vibration of the bees'

wings produces an increase in temperature for the hive. As seen from our exploration with thermochromic paper, the bees use the evaporation of water to cool the hive during the hot summer months.

*Steam Burns*

This link provides the reasoning behind why 100º C steam is more harmful to the skin than 100º C boiling water. Raising the temperature of 1 g of water from 37º to 100º requires 63 calories of energy. In order to convert this to steam, an additional 540 calories is necessary. When steam touches the skin, the extra energy needs to go somewhere as the steam cools to the temperature of the skin. This transfer of thermal energy into the skin has dangerous consequences. This directly relates to our discussion on the changes in energy associated with changes in temperature and states of matter. When a gas loses energy to condense into a liquid, that energy has to go somewhere. In the case of a steam burn, it goes to the skin.

Q25

CHEM 444AH

Chris Bauer

Due: February 24, 2015

*Ice Making in the East Indies*

1. In the East Indies, natives make ice overnight in large fields. They dig four to five foot squares into the ground, layer the bottom with sugar-cane, dry straw, or Indian corn stems, and set down shallow, porous, butter-smeared pans on top. The pans are filled with water in the afternoon and are left alone to freeze during the night. Early the next morning, the natives use iron hooks to remove the ice from the pan. The butter allows the ice to be removed without destroying the pan. The sugar-cane or other material prevent the pan from coming in contact with the heat of the earth. According to the observations of Barker and Williams, the water was more likely to freeze when the air was gentle, "sharp and thin" (as described by Barker). I'm not entirely sure what he means when he describes the air this way, but I assume he is discussing air pressure. As we learned using the PhET simulation, lower air pressure results in a lower temperature and the molecules slow down causing the substance to solidify. "Sharp and thin" air must be descriptive words for low air pressure, thus causing the water to freeze on calmer nights. Although I don't know if this is true, I would conclude that windier nights have a higher air pressure and thus the water does not freeze on these nights, even if the temperature outside is below the freezing point. These observations show that temperature is not the only factor of molecular phase changes.

2. After reading these articles, I can't help but wonder how these native people discovered this elaborate system to freeze water. They probably did not have much science research to study the behavior of water molecules. I don't understand how they could have possibly known that layering sugar-cane, dry straw, or corn stems could help the water molecules solidify. Perhaps they used trial and error and learn that the heat from the ground prevented freezing. I wonder how long it took them to figure out the best way to make ice. I also wonder where they store the ice that they make. Barker states that the ice they make in the winter months is enough to supply them for the summer. Where do they keep this ice where it stays intact for the summer?

*Sweating and Steam*

I chose to read the articles about sweating and steam because these are topics I have experienced in real life and can relate to. The common thread between them is the concept of heat of vaporization. Heat of vaporization is basically the measure of heat energy it takes to change a substance from the liquid phase to the gas phase. A lot of this energy is absorbed by the surrounding air and therefore doesn't change the temperature of the substance itself, which is what we observed with our graphs about phase changes. In our graphs, we showed increasing slopes with plateaus during phase changes which is exactly what is being described in the steam article. As the water starts to evaporate into steam, the energy is absorbed by the air around it (or by our skin), which is why the temperature of the water doesn't continuously increase throughout phase changes. The sweating article discussed this concept in that the heat energy causes the molecules to speed up so they can be released into the air. The molecules use energy to break off into the air. When we sweat and the water evaporates, we are releasing extra heat energy thus cooling ourselves down.

R23

Professor Bauer

Chem 444

2/24/15

Written Reflections Assignment

1. Making ice in the East Indies is not an easy process. This part of the world doesn't get natural ice therefore it must be made artificially. In order to make ice a lengthy arduous procedure must be completed. First large excavations, usually 30 feet square and about 2 feet deep, are dug into the plains. Then dry straw or sugar cane is placed at the bottom of the pits is about half a foot deep. On top of that are small shallow pans (usually smeared with butter). Right before dusk the pans are filled with soft (previously boiled) water. Then right before sunrise the ice-makers collect what is frozen in their baskets and move the blocks to the place of preservation (pits around 15 ft. deep). The ice is deposited in these pits and beat down until it creates one big solid mass. Then to protect the ice from the exterior a straw or blanket thatched roof is placed over the pit. The quality of the ice depends on the atmosphere and the weather. However it isn't evaporation that causes this change to happen. The straw or sugar cane is a good mediator of caloric which means that heat can travel easily between it and another substance. Therefore the heat given off by the straw into the atmosphere on clear nights causes the water to cool down thus creating ice. Having the ice below the ground prevents the surface from being affected. However the weather conditions aren't always apt to create ice. The best circumstances are calm and still air; even if that means that the temperature is slightly warmer. If the wind and temperature conditions are optimal then the water will freeze.

2. The process of making ice in the East Indies requires a lot of man power. According to John Lloyd Williams there are upmost 300 people employed to one area at a time. Nowadays it is relatively easy to obtain ice, however these people continue to do grueling work in order to make natural ice. This suggests that there is a cultural connection to the process. This practice was in place in the late 1770s and is still being used today suggesting that this process isn't going away any time soon. Maybe it has traditional significance or the ice-makers believe their ice is superior to modern ice. Whatever the reason I find it very interesting that they are continuing a process that takes up such a large amount of time and effort.
3. During the winter, the cold temperatures have the potential to be very damaging to fruit trees. However, properly maintaining a layer of ice on the trees works to protect the fruit buds. The concept called heat of fusion describes the heat required to convert a unit of a liquid into a solid without a change in temperature. This means that when water is frozen a small amount of heat is produced which allows farmers/gardeners to heat the fruit buds and maintain their temperature around $32^{o}$ Fahrenheit, or simply the ice stays the same temperature as the water instead of cooling down. However this is a very finicky process and the best way to go about this is with microsprinklers. These sprinklers only apply a light glaze to the trees instead of soaking them. This is important because in order to optimize protecting of the buds it is necessary to have minimal water vapor. Water vapor requires more energy than heat of fusion which is therefore damaging to the buds. This connects to our findings with the phase "graphs" that we all created. In all of the graphs that were made there was a slight dip or flat line at the melting/freezing point. In all of our experiments during the melting/freezing point the temperatures either stayed the same

or the slope of the graph decreased dramatically for a short amount of time. This is where the heat of fusion point is and at this point the substance stays the same temperature as it changes from a liquid to a solid or a solid to a liquid. This almost "in-between" state allows the flower buds to be right around 32 degrees and still be covered in ice. This also explains why getting the trees to this state is so hard. The heat of fusion phase is only during a specific time and in certain conditions and it doesn't take much variation of either to change the substance into a liquid or solid.

4. It is believed that steam burns can be more damaging to the skin than boiling water. This idea, in fact, is very correct. The steam contains more energy than the boiling water. We saw this in our own experiments with phase changes and the PhET simulation. As the phases go from solid to liquid to gas the amount of energy increases, as does the speed of the molecules. The molecules in the steam are moving much faster and contain more energy than the molecules of the boiling water. This difference in heat is called the latent heat of vaporization, which is the amount of heat energy necessary to change the phase or state of matter from liquid to gas. When a gas is condensed it must release its latent heat and become a liquid. This is usually not a problem because the extra heat is usually transferred into the air. However, if you place your hand in the steam the heat will be absorbed by your skin, and since the steam contains a lot more energy (heat) than the water it will be more damaging to your skin. Again all of this relates back to our own experiments with heat, kinetic energy, and phase changes. In order to advance from the stages of solid to gas the substance must hit certain temperatures and gain energy at each phase. Therefore even though boiling water is the step right before a gas it will still have a low temperature and less energy than the steam.

Assignment for February 24

1. **"Making Ice in the East Indies."**

This process works because as the water evaporates, it takes heat away from the remaining water, reducing the water's temperature. If the temperature is close enough to freezing, this process can remove enough of the heat to bring the water down to freezing point. The layer of plant material is necessary because it provides additional surface area beneath the pans for water to evaporate. This also prevents the water from absorbing heat from the ground. Being in a pit would protect the water from airflow, which seems to affect the ability of the water to freeze. One reason windy conditions may impact freezing is it would bring the warm air in contact with the water, which would raise its temperature. Also, a possible explanation for why wet plant material interferes with freezing is it would prevent the evaporation of water from the pans. This is similar to how sweat doesn't evaporate and cool you down when the air is humid. Porous, unglazed pans were more efficient because they provide the water with more opportunity to evaporate. As the authors describe, the outside of the pans became moist when filled with water. This means water would be evaporating from a greater surface area than if the water could only evaporate from the top of the water surface, such as in a glazed bowl.

I was surprised by the effort they put into producing ice in the 18$^{th}$ century. The authors describe using it to make ice cream and other frozen treats. I wonder if the hundreds of people they claim filled the pans and collected the ice also enjoyed the ice cream, or at least were able to use it to preserve meat. It seems unlikely.

2.

a. **Why We Sweat:**

Sweat is effective at cooling us down because of the process of evaporation. As water evaporates, it converts energy in the form of heat into kinetic energy. This removes heat from the water molecule's surroundings, including our bodies. We observed the effects of evaporation when we experimented with the thermochromatic paper. As water sat on the paper

and evaporated, it drew heat from the paper, resulting in a color change. This is the same process that occurs on our skin as we sweat.

**B. Protecting Fruit**

Farmers sometimes spray water on fruit trees to protect them from cold temperatures. This works because as the water molecules slow down enough to freeze, they must lose energy in the form of heat. The tree absorbs this heat, which helps it stay warm. This is the opposite of the process that allows sweat to cool us down.

T19

CHEM 444H

20 February 2015

Reflection Assignment for 2/24

1. From what I understand, the method described by Robert Barker and John Lloyd Williams works primarily because of evaporation. As we explored in class on 2/19, changing from a liquid to a gaseous state requires energy. The source of this energy can be thermal energy. When a liquid changes to a gas this energy transfer creates a cooling effect on the original source. In this ice making method, it is noted that more ice is formed when the air is dry and the wind is calm. These conditions allow for a greater amount of evaporation and a greater temperature drop. Increased humidity does not allow for as much evaporation because the air is already greatly saturated with evaporated water. The porous pans that the water is in also help because this creates less insulation to hold heat in and allows a greater surface area for evaporation.
2. At the end of his letter Robert Barker notes that this method could be very profitable in Asia because being able to freeze desserts such as custards and ice creams is a luxury. He states that the "principle study" in Asia is the luxuries of life. It is interesting that being able to freeze food is only being used for luxuries when there are many staple foods that could be kept frozen. It stands to show that "new technology" has always first been used for the pleasures of the wealthy and is only eventually put to practical use for the average person.
3. In class we have been talking about the energy needed to convert a solid to a liquid and a liquid to a gas. Energy (in the form of heat) is added to a substance until it reaches the

point that enough energy is present for a phase change to occur (enough energy is present to break chemical bonds). This explains why steam burns can be more harmful than burns from boiling water because steam contains more energy than boiling water. When it hits the skin it condenses because body temperature is lower than that of steam. The energy released is what causes damage to the skin.

4. The concept of bees cooling and heating their own hives also plays into what we have discussed in class. In the summer they bring water into the hive because as it evaporates the temperature decreases. This is because energy is being used to convert the water from a liquid to a gas. The energy comes from heat and results in a lower temperature in the hive. In the winter the bees huddle together and vibrate their flight muscles to generate heat through kinetic energy. They understand that the number of bodies in the hive also contributes to the amount of heat. More bodies correlates to increased energy production. More energy results in a greater temperature.

Steam

Bees

2/24/15
Chem444A

Reflection 1)

The process of making ice in the East Indies is not what one would expect. The process focuses entirely on the congelation of the substance rather than evaporation. It is imperative that the water first be boiled and then frozen because the closer two substances (air and water) are in temperature, the slower the changes (heating or freezing) will occur. Boiling the water forces the temperature of the water to reach a heat extreme while the late night/early morning air is at a cold extreme. An important factor when making ice is stable, clear weather opposed to cloudy, temperamental weather. The congelation does not take place in windy, unclear weather, which is why, to prevent a disturbance, the ice is covered with a blanket of material and a thatch roof to protect from exterior air. This process of making ice by artificial means in a part of the world where ice is somewhat scarce has proven to be beneficial to the community because it provides the region with not only a product/profit to drive the economy, but also the means to create, as Brocklesby states, "a comfortable refreshment as a recompence, to alleviate, in some degree, the intense heats of the summer season…" (257).

Reflection 2)

"Cooling the Bee Hive" perfectly demonstrates how energy is transferred from bee to bee within the hive. In order to maintain a high temperature to reproduce and raise the young, the bees, which are already vibrating and buzzing, cluster together so that the heat bounces off of one another and collides, creating more vibration and more energy, therefore creating more heat. The more bees, the more energy is being created within the hive, which is why when the hive

needs to be cooled, the bees distances themselves and sometimes send bees outside of the hive to lower the level of energy in the hive. This demonstrates how vibration and friction creates energy within a contained space and how a decrease in this energy/movement allows for the contained space to become cool. To assist in the cooling process, the bees also demonstrate a knowledge of evaporation used as a cooling mechanism.

Reflection 3)

The concept of an evaporative cooler, as the bees demonstrated, is explored in more depth in the “Swamp Cooler Guide”. Evaporation, as the website states, is the most efficient means of cooling air. This is because the temperature of the air tries to equalize with the temperature of the water present in the air, which is cooler. This is why when we used thermochromic paper to demonstrate the evaporation of methanol and water, even when all of the substance had evaporated, the sheet of paper still had a visibly colored area on it. The air above that particular spot was colder than the surrounding air because the substance had evaporated into it, making it cooler.

**Tuesday, February 24**

ICE MAKING

In warmer countries, the ability to make ice required creativity and an active knowledge of science. First, excavations would be made in the earth in order to hold the water. The bottom of these pits would be lined with sugar cane or dried corn. Then, earthen pans, which would hold boiled water, were placed into these pits. These pans were very porous. This means that when the water was poured into them, the outsides would become damp. Additionally, the corn and/or sugar cane were able to draw in the cold air and let it pass through to the water vessels. This drew away some of the heat from the boiling water and gave it the ability to freeze. Furthermore, it was important that the vessels were protected from the wind, because this allowed the water to settle and freeze at a quicker rate. On the topic of culture, it was amazing to me that 300 men, women, and children were employed in order to tend to these ice makers. In today's world, I can get ice from my refrigerator door by pressing a button. They had to have hundreds of people working around the clock in order to ensure that they had made ice.

SWEAT

Sweating is the natural way for your body to remove excess heat and cool itself down. People sweat for all different reasons, whether it is due to exercise, nervousness, or just the temperature. Converting liquid water to a vapor requires a certain amount of heat, or the heat of vaporization. This allows your sweat to evaporate into the air, but leaves the sodium, chlorine, and potassium behind on your skin, making it taste salty. Additionally, not all sweat can be evaporated

because of the humidity in the air. If the air is thick, there is already a lot of water in it, so sweat will usually stay beaded up and run off your body. If the air is dry, the air can take in more water and the sweat will evaporate. These ideas are consistent to what we have been seeing in the classroom. When we chilled different substances, they formed a more solid object. However, when they were warmed, they became a liquid. Finally, when more heat was applied (like your body exercising and needing to remove heat), some of the liquid was evaporated into a gas. That is why boiling water will stay at a constant temperature. Although heat is being applied to it, it is losing heat through vapor, or simply staying in equilibrium.

BEE HIVES

Bees are responsible for keeping the temperature of their hives in control. During the summer months, when the weather is hot, bees keep a distance from one another inside of the hive. This allows for air circulation. This is like when a room has a lot of people crammed into it, their body heat makes the room very hot. They also bring in water droplets and fan them in order to cool the hive with the evaporating water. As the water is going through a phase change, the air circulation from the wings help to spread the vapor. On the other hand, during the cooler times of year, the bees stay close together and create more heat through vibrating their flight muscles. This increase in work can be related to the Phet simulations. When the gaseous molecules were working more and bouncing around, the temperature increased because more energy was being used. Then, when they fly away from each other and don't move as much, like is seen in the solid state, there is less energy being used and less heat is given off.

X15
Professor Bauer
Chem 444
24 February 2015

Why does the ice-making process work?

First of all, by digging a hole to put the pans of water in, the water is prevented from being exposed to possible winds above ground, which disturb the water and keep ice from forming. The fact that the hole is additionally covered by a "thatched roof" to keep the water in an isolated, undisturbed area also helps to keep winds out. Since this situation is helpful but not foolproof, the most ice forms on nights when it is still and calm. The thick layer of sugarcane helps to keep in the cold, and their "spongy nature…gives a passage under the pans to the cold air, which may carry off by evaporation a proportion of the heat." The porous quality of the earthenware pans also aids the freezing process because since the water can soak through the material of the pan, there is less of a barrier between the pan and the cold air, and "the porous substance of the pans admits cold air internally." Additionally, this process must occur at night because the temperature is lower due to the lack of sunlight, and it will also be lower because the process occurs underground, separated from the warmer temperature of the air aboveground.

A sociological/economic/cultural observation:

I found it interesting that although the temperature in India never (or at least very rarely) fell below freezing and ice never (or rarely) seemed to appear naturally, people still discovered a way to create it for use. If ice was such a rarely occurring natural phenomenon, then how was the process of ice-making discovered and how did it develop into such an organized and prolific system?

Connections to 2 articles:

1. Swamp coolers or evaporative coolers rely on the natural cooling system of evaporation to cool air while using less energy. As substances change state from a liquid to a gas, they draw heat from the surrounding environment. Swamp coolers make use of this phenomenon by using a fan to drive hot air from the surrounding environment into the cooler. The water that is inside evaporates as the air passes through and cools the hot air, and then passes it back outside the cooler. 2. Steam burns can occur and can be more damaging to the skin than burns from water. This is due to the fact that there is more energy in steam than there is in water, which is a result of the latent heat of vaporization, the amount of heat necessary to change state from a liquid to a gas. As we have observed in class, it takes a significant increase in energy/temperature to change a substance from one state of matter to another because of the energy required to break molecular bonds. There is a certain degree of energy and heat in water that could burn you, but more heat and energy will be generated in order to break the water's molecular bonds and change it into a gas. The steam, having increased energy, will be able to cause significant burns.

It says that the process of the West Indies ice making began with boiling the water and putting it out at dusk then allowing it to freeze and retrieving it before dawn. It also says that the amount of ice produced depends on the weather. Since they explain the must boil the water before I assume it is part of the phenomena within their procedure. I believe their process works because they make it go from one extreme to another: boiling water to ice. They also get into the fact that in brisk cold nights the ice didn't freeze as much as when the nights were calm and slightly warmer night. I can't quite figure out an explanation as to why the water may freeze better when the temperature is warmer other than them saying atmospheric pressure was a factor. I assume that when it is colder and the atmosphere has a higher pressure than the molecules have more factors affecting them. When they weather may be a bit warmer with a stable atmospheric pressure than the substance can freeze quicker because the molecules will be affected more easily by the temperature and not need as drastic of a change.

Both articles clearly relate this specific procedure to the West Indies culture and how they use their own methods. I thought it was interesting how they set up the whole procedure and would use things like butter so that the ice could easily be removed.

The article claims that steam has more energy than boiling water and can be more injurious to the human skin. I agree with this based on previous readings and experiments conducted in class. For example, in the PhET simulation called "Gas Properties" we watched the speed of the molecules increase when the temperature increased and the speed decrease when the temperature decreased. This helped us prove that temperature had a direct correlation with the speed of the molecules and how something can change states. When the molecules have more energy they will be more likely to cause harm to someone's skin because it means they are hotter and most likely a gas. I believe this to be true

because when water goes from boiling water to steam it is changing states and gaining more energy. Therefore, when the steam touches the human's skin it has more energy to loose/transfer when coming in contact with the cooler substance and causes a more drastic change for both things.

The article also goes into the fact that the steam condenses on your hand and is what causes the damage/extent of the burn. Steam is at 100 degrees Celsius and when it touches the skin it is being cooled down, therefore changing states simultaneously and going through the process of equalizing the energy of the two objects or substances. So as the skin gains heat the steam must lose that heat. Our skin cannot go from a solid state to a liquid, or at least it's not supposed too, instead when our body is exposed to extreme temperatures of hot or cold we will either get frost bite or a burn. It kind of goes against what we have been learning with everything we've tested changing states when exposed to extreme temperatures, but everything has a different chemical makeup and different thresholds. As for the body, it has a different way of protecting itself from these changes.

Everything we do relates back to the effects hot and cold have on different substances and the human body is no exception. But, if when an object is heated up it changes to a liquid, yet our skin does not, do the atoms within our skin still increase in speed or do they just burn away as a form of protection?

Some farmers use a tactic of freezing their fruit trees when they know it's going to get cold by sprinkling them with water and allow a coating of ice to form. This is said to keep the fruit buds at a more constant temperature than when they are exposed to the cold. The fruit buds could be damaged if their temperature reaches a certain point, and even if the process is done incorrectly then it could be harmful. The way the claim it works to protect the plant from the colder temperatures it could be exposed to from wind chill and other factors because ice has a more constant temperature. I assume

this has something to do with ice being a solid and having more compact molecules compared to the cold are surrounding the trees. They also go into detail about how fruit buds are more sensitive to the cold in the beginning stages of their growth compared to when they actually begin to bloom. Although freezing something that is sensitive to cold sounds pretty counterproductive it seems reasonable the way they use the tactic.

The fruit buds have a certain threshold too cold before they begin to be harmed and although the temperature of ice is below that it is not nearly as damaging as the effects colder air temperatures could have on them. I don't quite understand how they used the heat of fusion or their definition. They state that it is "heat that's released when liquid water turns into ice". From this I assumed that it is because water in the liquid form loses heat in order to change states to a solid form of ice. Another way this is good for the plant is that the ice will no change back to liquid form until the temperatures are high enough for the fruit buds to endure.

Z11
Evaporative Cooling
24 February 2015

1. In the East Indies, ice was made by creating a ditch, scattering dry sugar cane or corn, and placing earthen pans filled with water over night. The authors of the articles observed that the temperature did not usually fall below the freezing point. They did note that the corn and sugarcane allowed a passage of air to pass under the pans. This allowed evaporation of water, such as described in the other articles provided. The evaporation of water provides a cooling effect, allowing the water to freeze.
2. I found it interesting that at the time the article was written, an maybe still so, ice never occurred naturally in the East Indies, and in the second article, the author said in the past year, the temperature ranged 95 and 100 degrees. Another interesting note was that about three hundred men, women, and children were employed in this whole process of filling pans in the evening and taking the ice out before dawn.
3. In the Bee Hive and Swamp Cooler articles, evaporative cooling was discussed. When bees are producing their young, they need to keep the hive at a constant temperature. They do this either by producing heat and staying close together or cooling down the hive by brining in water and fanning their wings across the droplet of water. The other article explains swamp coolers, nature's most efficient means of cooling through the evaporation of water. Evaporative coolers, or swamp coolers, draw exterior air into special pads soaked with water, where the air is cooled by evaporation and then circulated. These coolers are suited for areas/spaces where the air is hot and humidity is low. The liquid water molecules become gas in dry air, a process that uses energy to change its phase. The heat moves from higher temperature of air to lower temperature of water, giving off cooler air. Eventually the air becomes saturated by this water and is unable to hold any more water and the evaporation stops.